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Ageing, chronic conditions and the evolution of future drugs expenditures

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Ageing, chronic conditions and the evolution of future drugs expenditures

A five-year micro simulation from 2004 to 2029

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Abstract

- **Context**

The healthy ageing assumptions may lead to substantial changes in paths of aggregate healthcare expenditures, notably catastrophic expenditures of people at the end of the life. But clear assessments of involved amounts are not available when we specifically consider ambulatory care (as drug expenditures) generally offered to chronically-ill people who can remain in this health-status for a long time onward. The Government and Social Security need tools to predict the future cost of health in particular drugs expenditures taking account epidemiological changes on future. This study estimates the evolution in reimbursable outpatient drug expenditures, attributable to age structure and chronic conditions changes, of the French population up to 2029.

- **Methods**

Matched data from both the 2004 Health and Social Protection Survey (carried out by IRDES) and from French Social Security databases were used in this study. We estimate the effects of epidemiological and life expectancy changes on French health expenditures until 2029 by applying a markovian microsimulation model from a nationally representative database. The originality of these simulations holds in using an aggregate indicator of morbidity-mortality, capturing vital risk and making it possible to adapt the quantification of life expectancies by taking into account the presence of severe chronic pathologies. Three epidemiological scenarios were constructed.

- **Findings**

We forecast future national drugs expenditures, under different epidemiological scenarios of chronic morbidity: *Trend scenario*, *healthy ageing scenario* and *medical progress scenario*. For the population aged 25+, results predict an increase in reimbursable drug expenditures of between 1.1% and 1.8% (annual growth rate), attributable solely to the ageing population and changes in health status.

- **Conclusion**

The small difference between the healthy ageing scenario (1.1%) and the simple continuation of trends scenario (1.4%) indicates that, contrary to expectations, reduced chronic conditions of future cohorts does not imply a large saving in terms of drug expenditures.

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1 Introduction

In 2009, health expenditures in France reached 11.5% of GDP and are likely to keep growing into the future. At the macro level, this trend is explained by five main factors: demography (Bebbington and Shapiro, 2005), income effect², innovation, the health care system characteristics (public/private insurance, public policy and organization scheme) and the price effect (see Dormont, Grignon et al., 2006 for a decomposition of these effects on past trends).

In this paper, our attention is focused on the first factor and its future impact on drug expenditures. We propose an evaluation of the financial consequences of population age structure evolution (i.e.: proportion of old people in the population) and population size change, coupled with morbidity and mortality changes at the micro level.

Drug expenditures are the main contributor of the growth in the volume of global health expenditures (increase in health expenditures in France saw an average annual growth rate of 3.5% (in volume) from 2000 to 2008, while drug expenditures, during the same period, increased twice as quickly). Drug expenditures represented 20.5% of total health expenditures in 2008, or 544 Euros per inhabitant per annum, accounting for almost 2% of French GDP. Projections for drug expenditures therefore play a decisive role. The issues are industrial but also concern the financing of health expenditures, especially in the context of the recent growth seen in the use of generics together with the massive cut backs seen in drug reimbursements (in 2008, 65% of drug expenditures were reimbursed by the Social Security).

In the past, demography had weak impact on the growth of health expenditures. From French data, Azizi and Pereira, 2005 estimated that between 1970 and 1979 population ageing was annually responsible for 0.82% of spending growth with 0.65 points due to population increase and 0.17 points due to age structure changes. Dormont, Grignon et al., 2006 found, between 1992 and 2000, demographic changes were responsible for 7.63% or 0.92% annually. However the effects of demography will obviously be greater in the future with the baby-boomers reaching old age and the recent changes in longevity and health status.

In France, life expectancy at age 60 is increasing on average by two months every year, and one third of the French population will be over 60 by 2030 (WHO, 2006). Moreover, it is commonly postulated that drug expenditures increases as a function of age. In this framework, population ageing is expected to result in large drug expenditures increases into the future. However, the explanatory power of age has been criticized by Zweifel, Felder et al., 1999, who consider this demographic concern a “red herring” argument. Age is not a stable explanatory variable for health expenditures, since morbidity and mortality are changing over time. Health status and “time to death” explain most of the expenditure, greatly mediating the impact of age (Yang, Norton et al., 2003; Stearns and Norton, 2004; Shang and Goldman, 2008). Two possible scenarios are hypothesized to account for the observed increase in life expectancy and the likely impact on future health expenditures. First, medical and sanitary progress and healthier lifestyle choices have led to a longer healthy life expectancy (Olshansky and Ault, 1986; Nusselder, 2002; Oeppen and Vaupel, 2002). Second, medicine

² The income effect can be explained on both sides of the health care market. On the demand side, life styles have improved over the last decades. People are also more educated and so have higher expectations in term of treatments and quality of care. At the same time, the supply side is better endowed in resources.

and treatment have led to an increase in life expectancy without increasing life quality by transforming deadly illnesses into chronic conditions (Michel and Robine, 2004; Robine, 2007). In that second case, chronic conditions become a highly relevant predictor of health expenditures during the life cycle at the micro-level, specifically regarding out-patient cares (Druss, Marcus et al., 2001; Fenina, Le Garrec et al., 2009). The micro-level nature of these important epidemiological transition variables (health status, time to death) strongly suggest that it is hazardous to rely on macro-level economic models to accurately determine future health expenditures.

2 Methods

Three steps are necessary to construct this micro-simulation:

- (i) The definition of representative cohorts using a database created from large samples representative of the national population.
- (ii) The artificial ageing of individuals, carried out using transition rates between health states.
- (iii) The estimation of the drug expenditures vector, and finally the “simulation” of these expenditures, which consists in applying the vector to the artificially aged population.

2.1. Database

The data used in this study come from the joint use of a database belonging to the principal French health insurance providers - entitled “Echantillon Permanent d’Assurés Sociaux (EPAS)” (i.e. Permanent Sample of Social Security Contributors), with a French household survey entitled “Enquête sur la Santé et la Protection Sociale (ESPS)” (i.e. Health, health care and insurance survey), carried out by the Institute of Research and Documentation in Health Economics (IRDES).

EPAS comprises a panel of public health insurance recipients and contains exhaustive information about reimbursed expenditures by Social Security. The major advantage of this database is that it contains the exact values of out-patient expenditures, thereby avoiding any possible self reporting biases about healthcare consumptions. Note as well that the over-the-counter medications are not recorded by this administrative file. On the other hand, the organization of health insurance payments within hospital structures is such that drug expenditures are not individually accounted for, but form part of a “collective expense” (a sort of public ownership). However in France, outpatient drug expenditures account for 82% of total drug expenditures reimbursed by the public health care system, and are therefore driving the growth of reimbursed drugs expenditures.

The ESPS has been carried out using a self-administered survey every two years since 1988 in metropolitan France on a sample of 7,000 Social Security contributing households, or 22,000 individuals which are representative of over 96% of the French population. This database contains a great deal of information about Social Security contributors: individual and household data, demographic and epidemiological characteristics (notably several summary

indicators of health status), socio-economic data, and information about individuals' insurance coverage.

In France, the ESPS coupled with the EPAS forms the only database cross-checking exact individual health expenditure with accurate information about insured. This database contains 10,328 observations of which 6,996 were exploitable for this study. The data were adjusted using calibration on margins (for age, sex and for household income) in order to obtain a representative sample of the global metropolitan population of 62.4 million individuals.

2.2 The chronic conditions measure

Morbidity rates and healthy life expectancies, for a given cohort, change over time and modify the relationship between age, health status and health expenditures. As a result, age is not a stable determinant of health expenditures (Dormont, 2009).

For example, Shang and Goldman, 2008 found a strong link between expenditures and self assessed health (SAH) after controlling for age. Indeed, age lost significance when SAH was introduced into the regression. The effects of age were thus explained by health status.

As well, the literature highlights that end of life expenditures explain the biggest part of the observed increase in expenditures associated with age, as the probability of dying is an increasing function of age (Zweifel, Felder et al., 1999; Yang, Norton et al., 2003; Stearns and Norton, 2004). Authors insist on the need to introduce a 'time to death' variable in the estimations, relating end-of-life expenditures with intensive care at hospital. In this paper we do not observe hospital spending but rather focus on another contributing factor than end of life: chronic illness and its potential compression, or expansion, within future cohort of older people (Stuckler, 2008). This variable of "chronic disease" better characterizes the (possibly long) life-history of people after 60 and is a better predictor of ambulatory expenditures, such as drugs. Thus, we need to determine a health status indicator which enables the evolution of chronic morbidity to be modeled, and more important, which gives us a consistent explanatory variable for the econometric model.

Various instruments for measuring health status are available. We usually find three main dimensions in health measurement (Blaxter, 1989): lists of diseases and symptoms (medical model), activity limitations (functional model) and self-assessment health (SAH) measures (subjective model). To sidestep this difficulty IRDES researchers have built two health status indexes, vital risk and disability. These scores have been provided by doctors on the basis of ESPS database (Mizrahi and Mizrahi, 1985). Vital risk corresponds to the death likelihood level and is built from illness and individual risk factors. It is rated on a 6-point scale from "no essential risk" to "a definite poor prognosis" which reflects an 80% probability of death within five years. Disability level induced by chronic conditions and is rated on an 8-point scale from "no impairment" to "permanently bed-ridden".

A chronic condition is one which medical treatment can alleviate but not cure. It is commonly described as a long-lasting or recurrent disease which generates disability. To capture those dimensions, we used the previous indexes to construct an aggregate binary index of health status by crossing the two variables³ of vital risk and disability, as described in appendix 3. The proxy variable for chronic conditions is composed of two modes: healthy e_1 and

³ Note that the frontier has been chosen according to the classification made by Perronnin, M., L. Rochaix, et al. (2006). "Building a continuous indicator of state of health aggregating vital risk and disability (Construction d'un indicateur continu d'état de santé agréant risque vital et incapacité)." *Questions d'Economie de la Santé*(107).

unhealthy state e_2 . Thank to this synthetic indicator, it is not necessary to consider the whole range of diseases in order to predict future health expenditures. Furthermore, the problem of poly-diseases (i.e. co-morbidities), which are very frequent in those aged over-60, is immediately accounted for. The unhealthy state refers to serious pathologies or chronic diseases (e.g. diabetes) for which complete remission is not generally possible. Accordingly in the model, state e_2 is semi-absorbent (i.e. it is not possible to pass from e_2 to e_1).

2.3 The microsimulation model

2.3.1 Artificial ageing of the database

To simulate an individual's future health status, we use an ageing algorithm based on Markov's process (Briggs and Sculpher, 1998). The artificial process of ageing needs the construction of transition rates matrices, which contain probabilities of transition from one health status to another. We consider a matrix constructed by age group (each age group being equal to 5 years) and by sex. We therefore identify 72 types of people (19 age groups + 2 sexes + 2 health statuses; therefore 38 matrices containing 3 states of which 1 is an absorbing state - i.e. death) for which the pathway probabilities from one health status to another are different. At time t , an individual is either healthy or unhealthy. Then, at $t+1$ (i.e. five years later), health status will be determined by the probabilities of the transition matrix which he/she belongs to, knowing that his/her lottery (i.e. the line of the matrix) depends on his/her state of health at t .

Therefore, the epidemiological dynamic is written as:

$$\bar{e}_{n,t+1} = \bar{e}_{n,t} \left(\dots P_{e_i/e_j} \dots \right) = \bar{e}_{n,t} [\Gamma_t]$$

with $\bar{e}_{n,t}$ individual health status n at time t and P_{e_i/e_j} being the probability of transition between state i and state j .

These 5-year probabilities are arranged in the transition rate matrices as follows:

$$\Gamma_t^{sex} = \begin{pmatrix} P_t^{sex}(e_1 \rightarrow e_1) & P_t^{sex}(e_1 \rightarrow e_2) & P_t^{sex}(e_1 \rightarrow e_3) \\ P_t^{sex}(e_2 \rightarrow e_1) & P_t^{sex}(e_2 \rightarrow e_2) & P_t^{sex}(e_2 \rightarrow e_3) \\ P_t^{sex}(e_3 \rightarrow e_1) & P_t^{sex}(e_3 \rightarrow e_2) & P_t^{sex}(e_3 \rightarrow e_3) \end{pmatrix}$$

2.3.2 Construction of epidemiological scenarios

In 2004, according to World Health Organization (WHO), the French spend on average 7.7 years in poor health and can expect to remain in good health 90% of their lives (WHO, 2006). France is thus in a position of dynamic equilibrium (Manton, 1982; Robine and Michel, 2004) characterized by an increase in prevalence of chronic diseases, offset by a lower severity (Robine, Mormiche et al., 1996). We must therefore distinguish two epidemiological effects. On the one hand, the morbidity compression delaying the onset of disease in the life cycle and leads to longer life expectancy (Fries, 1980; Crimmins, 1990; Robine, 1992; Khaw,

1997; Nusselder, 2002). On the other hand, the expansion of morbidity is defined by extending the unhealthy life expectancy (Kramer, 1980; Fuchs, 1984).

Population ageing is proposed according to three different scenarios of morbi-mortality. Except for the trend scenario, the previously calculated transition matrices are “deformed” in order to integrate epidemiological ageing hypotheses, basically by shifting transitions rate of the younger cohort to the older one. However, the shift is differentiated by sex. Meslé, 2004 found accelerated growth in life expectancy and morbidity compression for males when compared to females, due to an increase in healthier behaviors on the part of men. Indeed in 1990, the gap in life expectancy at birth was 8.2 years in 1990 and against men, it is in 2008 equal to 6.7 years.

Consequently we chose to differentiate between male and female morbidity (second and third scenario) and mortality (third scenario) evolution. To this end the shift is 10 years for men but only 5 for women. Thus men are catching up with women in terms of healthy life years and life expectancy.

- Trend scenario

Incidence and death rates are held constant with rates observed in 2004. The risk of falling ill is defined by reference to 2004, and we only take into account longer life span known as of 2010. The matrices correspond therefore to current morbidity rates, which come directly from the cross-sectional analysis of the ESPS2004 database. Accordingly, after simulating the drug expenditures, we obtain the degree of increase in expenditures linked only to the demographic effects arising from the deformation of the age pyramid. The predicted expenditures within the framework of this scenario consequently are only the result of continuation of trends.

- “Healthy ageing” scenario

This scenario is based on the hypothesis of reduced morbidity while mortality rates remain constant with the trend scenario. In order to obtain the healthy ageing scenario matrices, we reduce the probabilities of becoming chronically ill. Hence the probability of staying healthy is improved by the same magnitude as we do not change the death rates of the healthy population.

This way reflects rejuvenation by a shift in biological age which is now distinct from chronological age - and therefore improves health status of future populations. From the shift in probabilities, we redefined the degree of longer life span through its redistribution between healthy and unhealthy days. This hypothesis translates Robine, 2007 theory on ageing and the rectangularization of the survival curve: longer life results from an improvement in health states.

- Medical progress Scenario

In this scenario, the healthy ageing hypothesis is kept. We add a hypothesis of reduced mortality for healthy and unhealthy people. Thus, we suppose that the future will bring a reduction in mortality rates of unhealthy (by the transformation of fatal pathologies into chronic ones). This is an extreme healthy ageing scenario, characterized by a complete rejuvenation of age groups, incorporating a longer life expectancy. This scenario corresponds to the modeling of medical-technical progress which, for unhealthy people (having passed into state 2), increases their life span. Here, “medical progress” is only defined in terms of its demographic and epidemiological impacts (e.g, no scenario for changes in prices is tested).

2.4 Estimation of drug expenditures

2.4.1 The Econometric model

In order to project drug expenditures, we have used an econometric model based on individual data. Generally, the econometric treatment of health expenditures requires particular characteristics to be taken into account, notably the presence of individuals who have had no consumption of drugs for a whole year.

Although several estimation techniques are available, the analysis of the characteristics of the EPAS-ESPS2004 data determines the most suitable econometric model for drug expenditures. Twelve point five percent of the population had no drug expenditures in 2004. Based on Jones, 2000 and Deb and Trivedi, 2006, the “two-part” model seems the most appropriate to deal with the problem of “zero expense”, as it separates consumption behavior into two steps. First, the individual decides whether to consume or not (part 1), and then he/she decides the degree of consumption based on different factors (part 2). The global model (i.e. the conditional mathematical expectation of expenditures) is obtained by multiplying the probability of the decision to consume by the estimated conditional expenditures:

$$E(y_i / x_i^{p1,p2}) = \Pr(y_i > 0 / x_i^{p1}) E(y_i / x_i^{p2}, y_i > 0) \quad (1)$$

Where y_i is the individual level of expenditures and $x_i^{p1,p2}$ is the vector of the expenditures explanatory co-variables (part 2) and of the decision to consume (part 1). The choice of such a modelization is also justified by the flexibility it brings to the model, by dividing the mechanism of consumption into nearly independent parts. The first part of the model (i.e. the probability of consuming), is estimated using a Logit:

$$\Pr(y_i > 0) = \frac{1}{1 + e^{-x_i^{p1} \beta}} = \frac{e^{x_i^{p1} \beta}}{1 + e^{x_i^{p1} \beta}} \quad (2)$$

Where $x_i^{p1} \beta$ is the expression of the predictions (x_i^{p1} the explanatory co-variables vector and β the vector of parameters estimated from the Logit model)

To model the second part of health expenditures we have the choice between two main types of models: generalized least squares models (GLM), and ordinary least squares (OLS) models with transformation of the dependent variable (see Manning and Mullahly, 2001; Buntin and Zaslavsky, 2004 for an algorithm to determine the best data fitting method). Having tested both alternatives, the GLM was rejected due to flatness in the distribution of residuals (indicated by the kurtosis coefficient). An OLS log-transformed model, re-transformed using a smearing factor, was identified as the best fitting model for projections of drug expenditures based on EPAS-ESPS2004 (Duan, Manning et al., 1983).

3 Results

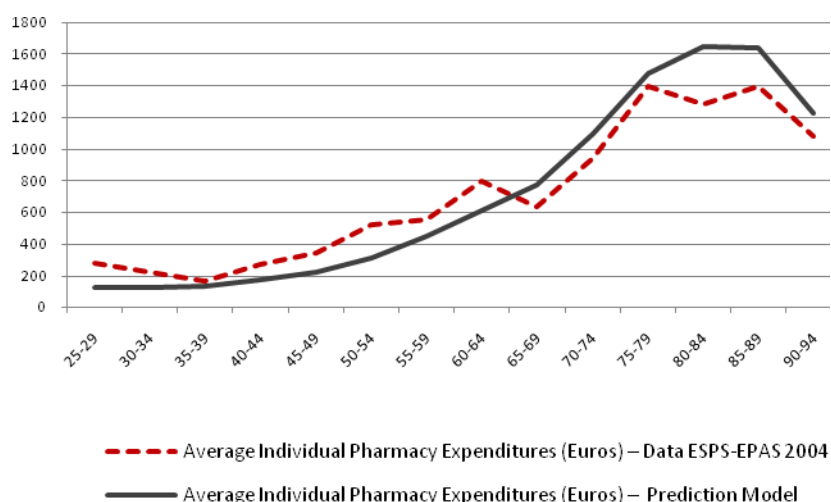
3.1 Econometric model predictions

According to the methodological section, we proceed with the implementation of the two regression models, first in the general population and then in the consuming population. The result of these regressions is presented in appendices 2 and 3. Especially note that the health

status indicator is highly significant and captures well pharmaceutical expenditures heterogeneity in both parts of the model. Indeed, it appears to be the strongest expenditures predictor, while the impact of age remains very small. “Chronic conditions” is indeed playing the same role for ambulatory expenditures as “time-to-death” in the inpatient expenditures case.

Figure 1 enables the quality of predictions to be evaluated by establishing the comparison between the “real” expenditures (i.e. those coming from the database) and those which the model predicts for 2004. We then execute the model on the 2004 ESPS-EPAS survey data and simulate pharmacy based expenditures for 2004. The model respects the profile of expenditures very closely, in particular replicating the drop in expenditures after 80 years of age.

Figure 1. Comparison of real expenditures with predicted expenditures



3.2 Projected Populations and drug expenditures

The simulations of different ageing scenarios for individuals enable the assessment of the effects of epidemiological changes on the demographic structure of the population to be carried out. Table 1 confirms the significant increase in the over 60 population, which practically doubles in size in the medical progress scenario. Moreover, this artificial ageing model is true to INSEE’s (National Institute of Statistics and Economic Studies) predictions, their trend scenario predicting 19.7 million people aged over 60 years by 2030 (Léon and Godefroy, 2006). However, the scenarios clearly differ in terms of the distribution of elderly people between the “sick” and “not-sick”. In 2004, 51% of the over-60 population was unhealthy.

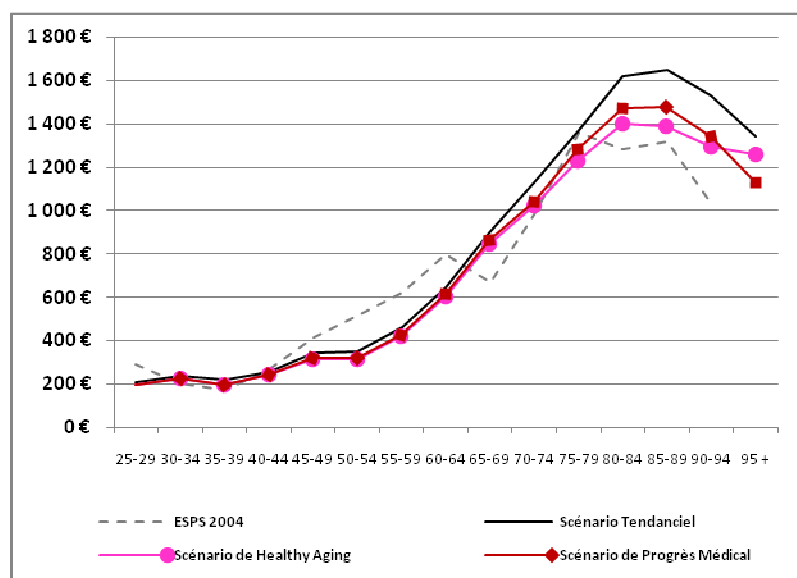
Whatever the scenario, the proportion of unhealthy people increases in the general population (+25). 27% of people aged 25 and over is in poor health in 2004. In 2029, this number reaches 36% in the trend scenario, 29% in the healthy aging scenario and 33% in medical progress one. The examination of an older population increases the prevalence of the disease but only in the trend scenario and medical progress. In 2004, 51% of the population over 60 is unhealthy. In 2029 this proportion was 58% in the baseline scenario, 48% in the healthy aging scenario and 54% in that of medical progress.

Table 1: Population (in millions) in 2004 and 2029 according to 3 scenarios and distribution between the sick and people in good health

	ESPS 2004	Trend Scenario	Healthy Ageing Scenario	Medical Progress Scenario
Population ≥ 25	42,62	49,38	49,93	53,46
Whose healthy people	30,98	31,75	35,45	35,68
Whose unhealthy people	11,65	17,63	14,47	17,77
	≥ 60			
Population ≥ 60	12,66	20,87	21,41	24,83
Whose healthy people	6,16	8,84	11,21	11,44
Whose unhealthy people	6,50	12,02	10,20	13,39

Figure 2 shows the impact of the hypotheses of decreased morbidity (i.e. longer lifespan in good health) when underpinned by the healthy ageing and medical progress scenarios. Because in these two cases, the population is in better health than in the trend scenario, the average expenditures per age group are inferior. Mean expenditures in the medical progress scenario, which include a longer lifespan of both the sick and not-sick, are nevertheless higher than those for the healthy ageing scenario. In effect, in the former scenario, there is a greater number of unhealthy survivors.

Figure 2. Average individual drug expenditures according to age and scenario



Population ageing, even with healthy ageing, seems to be responsible for a significant increase in drug expenditures (Table 2). The simple effect of ageing in the French population should lead to an increase of 43% in drug expenditures for those over 25 years old (when compared with 2004 and the trend scenario). The healthy ageing hypothesis limits this increase only slightly as drug expenditures continue to grow substantially, increasing by 33%. The medical progress scenario predicts a much stronger increase. Expenditure from now until 2029 could reach more than 35 billion Euros instead of the 22 billion Euros in 2004.

Table 2. Drug expenditures in 2004 and in 2029 according to the 3 scenarios and distribution between the healthy and unhealthy people (in billions euros)

	ESPS 2004	Trend Scenario	Healthy Ageing Scenario	Medical Progress Scenario
Expenditures people ≥ 25	22,66	32,41	30,10	35,15
<i>Whose healthy people</i>	8,25	9,19	10,81	10,92
<i>Whose unhealthy people</i>	14,41	23,19	19,28	24,22
	≥ 60			
Expenditures people ≥ 60	12,40	23,87	22,15	27,14
<i>Whose healthy people</i>	3,50	4,35	5,69	5,80
<i>Whose unhealthy people</i>	8,90	19,48	16,46	21,34

4 Discussion

Longer life span is a matter of great debate amongst epidemiologists. In the future, shall it concern the compression of morbidity linked to an improvement in individual behaviours (e.g. improved daily hygiene and new knowledge in terms of preventive medicine (Fries, 1980; Crimmins, 1990; Robine, 1992; Nusselder, 2002) or instead shall it concern the development of medical progress and the nature of pathologies in elderly people, with a resulting automatic increase in the number of people living with chronic diseases Kramer, 1980; Fuchs, 1984? In the first case, the increase in life expectancy would be the result of increased life expectancy in good health, while, in the second case, life span while living with chronic disease would be prolonged.

As economists, we take no position about these theses. Instead we provide the means to evaluate the consequences of both. We propose the scenarios reflecting these two alternatives, in order to evaluate their differential impact using the means of microsimulation. The originality of the study is also to use a health status variable indicating “chronic condition” which is appropriate for the prediction of ambulatory healthcare expenditures. Our results indicate that, despite the improvement of the health status of elderly and the large significance of the variable in elderly individual’s health consumptions, their expenditures are not considerably reduced in 2029, firstly because of a volume effect of elderly age-groups, who, from 2010 onwards, are particularly numerous in France. Moreover, unhealthy people drug expenditures go on growing with age, as the profile of expenditures does not depend solely on people’s health. Delaying the date of onset of chronic disease, the expenditures are not completely postponed. The healthy ageing scenario therefore would not be very “cost saving”, as it does not compensate for the predicted growth in the number of elderly people in France in 2029.

Several hypotheses had to be carried out in order to make the technical treatment of this microsimulation possible. In our model, health status is summarized by a binary variable which does not take into account various levels of the seriousness of the state of the disease, nor the progressivity in the volume of medicine consumed by the sick, which is something that constitutes a limit of this tool. It does, however, involve the interaction between two different measurements of health state both diagnosed by medical professionals and consequently not self-declared. This important fact in turn limits individual heterogeneity biases. Moreover, the state of illness is seen as “absorbing”, that is to say that no remission is possible. Accordingly, this hypothesis, imposed by the complexity of the transition matrices, tends to overestimate the number of sick people and therefore the volume of medicines

consumed. We have tried to limit the consequences of this constraint by considering as “sick” all those persons who had a “very poor” life prognosis.

The choice of scenarios can determine the nature of the results. We decided to consider that a global scenario of the expansion of morbidity did not appear a likely option. Obviously, it would appear necessary to follow the increase in the prevalence of diabetes and obesity, two illnesses which are likely to induce new drug expenditures. Besides, in order to construct the healthy ageing scenario, we decided to shift (back) men of two age brackets, with one age bracket for women. A greater degree of shift would obviously increase the effects of the scenario on expenditures. Nevertheless, we recognize that this assumption seems already relatively optimistic, and so we opted for a situation where the measured differences gave results which are *a priori* magnified.

Despite these limits, rates of growth in drug expenditures seem relatively consistent with results from the literature. With regards to French data, two studies can be mentioned regarding total health expenditures (no estimations are available for drugs only). The OECD, 2006 estimates that between 2005 and 2025 population ageing would annually account for +1.76% in the pessimistic assumption (increase of life expectancy trends are accounted for but the current age expenditures profile remains constant) and for +1.43% in the optimistic assumption (they propose a healthy ageing scenario in the sense that their expenditures age profile progressively shifts to the right). The European Commission and Economic Policy Committee, 2006 estimate that between 2004 and 2030, demographic-related growth will annually account for +2.1% in the pessimistic assumption and +1.87% in the optimistic assumption.

5 Conclusion

To our knowledge, this work is the first prospective microsimulation model for determining drug expenditures in France by the year 2029. It allows considering the acceleration of the ageing population due to high fertility after the second world-war. Our results show the sensitivity of drug expenditures projections to demographic and epidemiological changes (including increase of chronic diseases of elderly). In addition to a baseline scenario, we decided to test a hypothesis of delayed age of disease (healthy ageing) and a scenario additive increases in life expectancy (medical progress).

The pure effect of ageing of population in France is expected to generate an increase in drug spending of 43% (comparing 2004 and the trend scenario) equal to 1.44% of annual rate of growth). The assumption of healthy ageing is only slightly limiting growth. Drug spending continues to grow substantially, with a total increase of 33% (1.14 % of annual growth rate). The scenario anticipates medical advances grew significantly stronger. We notice that longer life span, notably for unhealthy people (i.e. the medical progress scenario), further accentuates the growth in drug expenditures associated with ageing. Drug expenditures by 2029 could reach more than 35 billion Euros against 22 in 2004 (1.77% of annual rate of growth).

Of course, these evaluations constitute a *ceteris paribus* prediction in terms of the evolution of pharmaceutical expenditures in France – i.e. it only takes account of the “automatic” effect of ageing and changes in morbidity. These rates of growth in drug expenditures are the minimum rates.

The drugs regulation policy of the French health care system could also play an important role in the future of reimbursed drugs expenditures. First, the authorization for the drug market is highly regulated. Reimbursed Drug Prices (and reimbursement rate) are not Market Prices but negotiated between the relevant public authorities and the pharmaceutical industries. Drug Volumes partially depend on Parliament regulation. Any change in this policy (e.g. a decrease of reimbursement rate) can modify the dynamics of drug expenditures, in value and perhaps in volume.

Other factors will play a role as follows: therapeutic decisions favoring the use of medicines (e.g. substituting surgery or other therapeutic actions for medicines, or innovations in available molecules); modification of relative prices; intensification of the demand for healthcare (cultural reasons). Healthcare seeking behaviors are also dictated both by the level of drug expenditures reimbursement and the level of coverage provided by complementary health insurance.

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Appendix 1. Transitions states

Table 3: Example of transition rates for female aged 50 to 59 years old

Female	P(e1->e1)	P(e1->e2)	P(e1->e3)	P(e2->e2)	P(e2->e3)
Trend					
50-54	0,9102	0,0825	0,0072	0,9781	0,0218
55-59	0,8908	0,1001	0,0091	0,9723	0,0277
HA					
50-54	0,9266	0,0661	0,0072	0,9781	0,0218
55-59	0,9102	0,0805	0,0091	0,9723	0,0277
MP					
50-54	0,9266	0,0681	0,0052	0,9843	0,0157
55-59	0,9102	0,0825	0,0072	0,9781	0,0218

Appendix 2. Descriptive Statistics

Table 4. Co-variable descriptive statistics

Variable	Modality	Distribution (%)
Sex	Men	47.15
	Women	52.85
Health state Indicator	In good health	72,67
	Chronic Disease	27,33
Complementary Health Insurance	Has Com Health Ins	88.01
	Does not have Comp Health Ins	11.99
CMU* (Special Public Complementary Insurance)	CMU recipients	4.25
	Not a recipient of CMU	95.75
Body Mass Index (BMI)	Underweight	2.80
	Overweight	31.54
	Obese	12.54
	Normal	53.11
(Public) Health Insurance Regime	Special Regime	24.28
	General Regime	75.72
Alcohol Profile	Non drinker	24.04
	Not at-risk drinker	48.55
	At risk drinker	27.41
Tobacco	Smoker	23.81
	Non smoker	76.19
Doctor Density	High Doctor density	50.60
	Low doctor density	49.40
Couples	Not living in a couple	22.11
	Living in a couple	77.89

* CMU is a public supplementary health insurance program which grants free of charge to those households with an annual income of around 9,000 Euros or less.

Appendix 3. Building the binary chronic conditions variable

To build the health status indicator we cross the vital risk and the disability variable as follow :

Table 5. Binary Chronic conditions status

		Disability Index							
		0	1	2	3	4	5	6	7
Vital Risk Index	0	Healthy Status							
	1								
	2								
	3	Unhealthy status							
	4								
	5								

Table 6. Items of the Disability Index

0	No Disability
1	Minimal Disability
2	Few Disability
3	Disability, but Normal Living
4	Have to Decrease Professional and Household Activities
5	Low Autonomy
6	No Household Autonomy
7	Full time Confinement to Bed

Table 7. Items of the Vital Risk Index

0	No Vital Risk
1	Very Low Poor Prognosis
2	Low Poor Prognosis
3	Possible Vital Risk
4	Poor Prognosis
5	Very Poor Prognosis

Appendix 4. Estimation of the probability of being a consumer of reimbursed medicines

Table 8. Association of predicted probabilities and observed responses

Concordant Percentage	73.6	Somers' D	0.477
Discordant Percentage	25.9	Gamma	0.480
Ties percentage	0.5	Tau-a	0.106
Pairs	1627968	c	0.739

Table 9. The logistic model: the probability of being a consumer of reimbursed medicines

Odds Ratios			
Effect	Estimated Point	95% Wald Confidence Interval	
Has a Chronic disease	2.785	1.975	3.928
Age	1.007	0.780	1.300
Age ²	0.999	0.994	1.004
Age ³	1.000014	1.000	1.000
Has complementary Health insurance	2.571	1.822	3.627
CMU recipients	4.674	1.926	11.343
General Insurance regime vs Special Insurance Regime	1.712	1.308	2.240
Living in a couple	1.366	1.038	1.798
Women	2.026	1.563	2.628
High Doctor Density VS Low Doctor density	1.292	1.049	1.592
Y = 1 represents 12.48% of the weighted sample of those over 25 years old			

Appendix 5. Estimation of expenditures for reimbursed medicines

Table 10. Statistics of OLS model

R-square	0.3926
Root mean square of error	1.2366
Degrees of freedom	3335

Table 11. Estimated coefficients of regression

Parameter	Estimation	Standard error	t Test value	Pr > t
Constant	6.1433204	0.78592090	7.82	<.0001
Has a Chronic Disease	1.0814673	0.05681064	19.04	<.0001
Age	-0.1994922	0.04617721	-4.32	<.0001
Age ²	0.0043394	0.00086101	5.04	<.0001
Age ³	-0.0000253	0.00000494	-5.12	<.0001
Health Insurance	0.3402625	0.08741645	3.89	0.0001
CMU recipients	0.5041919	0.18191389	2.77	0.0056
Body Mass Index (BMI) Normal	Reference			
BMI Underweight	0.3997516	0.16217829	2.46	0.0138
BMI Overweight	0.1619703	0.05054641	3.20	0.0014
BMI Obese	0.3142043	0.07027668	4.47	<.0001
Alcohol profile : at risk Consumer	Reference			
Alcohol profile : non Consumer	0.4052201	0.07552941	5.37	<.0001
Alcohol profile : not at risk Consumer	0.1887194	0.06445822	2.93	0.0034
Women	0.2753358	0.05587362	4.93	<.0001
Non-smoker	0.1615484	0.06053003	2.67	0.0076

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